JULY, 1920 EXTENSION CIRCULAR No. 105

Green Clover Worm
AS A
Pest of Soybeans

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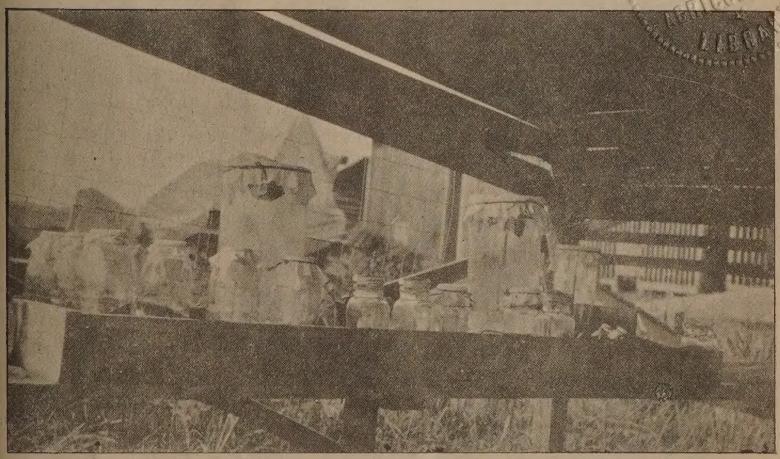

Ascertaining the Facts. Portion of Field Laboratory at Terra Ceia, N. C., August, 1919 (Original)

N. C. State College of Agriculture and Engineering
N. C. State Department of Agriculture
N. C. Agricultural Experiment Station, and
U. S. Department of Agriculture, Cooperating

Agricultural Extension Service

B. W. KILGORE, *Director*

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REEN CLOVER WORM AS A PEST OF SOYBEANS WITH SPECIAL REFERENCE TO THE OUTBREAK OF 1919

By Franklin Sherman, *Chief in Entomology*
and
R. W. Leiby, *Assistant Entomologist*

INTRODUCTION

During July and August, 1919, there occurred throughout the eastern lf of North Carolina a sudden and widespread outbreak of a green erpillar, often called a "measuring-worm," which rapidly ate away e leaves of soybeans, stripping whole fields until they looked as if rched by fire. Beginning in the latter part of July, the injury sub- ed by the middle of August, and many fields, especially of later ma- ring varieties, quickly put out new growth and recovered, but in many es the earlier maturing varieties were ruined.

This was the Green Clover Worm (*Plathypena scabra,* Fabr),* an ect long known to be present in the State, and native to practically e whole of the eastern half of the United States. The larva or cater- lar is well known to feed upon the foliage of many kinds of legumes, d some other plants.

As this was the first time that widespread defoliation had occurred our soybean fields from any insect, and as little was known as to the ect of poisons or other insecticide materials on the plants, an investi- tion was at once begun, which showed that prompt (very prompt) sting of the plants with dry arsenate of lead powder mixed with dust ne at rate of 1 pound of arsenate to 8 pounds of lime, gave a satisfac- y control. The studies showed that the insect has several natural emies which ordinarily must hold it within bounds—indeed an insect rasite was important in preventing another destructive generation in ptember.

PAST HISTORY

While the Green Clover Worm has for many years been known as a st on clover and alfalfa, its seriously destructive outbreaks have been egular. In the Mississippi Valley and in New England it has at nes been a serious pest on garden beans. In North Carolina we have ng known the insect as common, but had never known the caterpillar do extensive damage, although inquiries during the outbreak of 1919 dicated that a similar worm, perhaps the same, had sometimes done me injury.

*Order *Lepidoptera;* Family *Hypenidae* (*Noctuidae,* broad sense).

OUTBREAK OF 1919

The 1919 outbreak of Green Clover Worm extended from northern Florida to New England, and in North Carolina was intensive throughout the eastern half of the State. It was observed on snap and pole beans but the complaints referred exclusively to its work on soybeans. Its work was evident in thousands upon thousands of acres, probably half of the total soybean acreage in the State was seriously attacked by the July-August brood of caterpillars. Fortunately the outbreak was brief and thanks partly to natural enemies the following generation was not seriously destructive.

POSSIBILITIES FOR THE FUTURE

The insect has long been native. The planting of extensive areas in soybeans is a new development. Inquiries during the outbreak indicate that similar injury had been experienced before, but never on such an extensive scale.

As the caterpillar lives exposed to the attacks of natural enemies and as each generation matures in only a few weeks, it is probable that this pest, like the army-worms and cotton-caterpillar to which it is somewhat related, will continue to be erratic and irregular in its destructive outbreaks; but, also, owing to the development of our soybean industry, and as the insect evidently takes well to that plant, we must conclude that we are liable to occasional outbreaks in our soybean fields. During the present century it did not earn a place on our list of destructive insects of the State until 1919; we can hardly expect it to remain obscure for another nineteen years. Rather, we would expect that at irregular intervals it may gain destructive abundance for a short time then to subside again as its natural enemies once more bring it within bounds, or when the farmer checks it with the prompt (*very prompt*) application of remedies. It is reasonable to assume that it will rarely appear in such numbers as it did in 1919. It is impossible to make any positive prediction.

INVESTIGATIONS IN 1919

Field Stations.—After a preliminary survey at end of July, two temporary field stations for study of the Green Clover Worm were established, one at Terra Ceia, Beaufort County, operated by Mr. R. W. Leiby, and the other near Elizabeth City, Pasquotank County, by Mr. F. Sherman. Studies and tests were made in fields, and insects in cages were under constant observation. Occasional trips through the affected area kept touch with the general progress of events.

Susceptibility of Varieties.—It was noted that varieties which had completed most of their growth when defoliated in late July and early August were not able to make adequate recovery. On the other hand, the longer-growing varieties, which had not yet attained full size,

covered quickly by putting out new growth after the attack subsided, ded by timely rains. This matter is further discussed in the last pages this circular.

LIFE-HISTORY OF GREEN CLOVER WORM

Like all other moths and butterflies, the Green Clover Worm has four parate stages in its life: (1) the adult moth, which lays eggs and es; (2) the egg, which is laid by the moth, and which hatches to the terpillar; (3) the larva or caterpillar which hatches from the egg, hich does all the destructive feeding, and which, when grown, changes the pupa or chrysalis; (4) the pupa or chrysalis, which develops from e caterpillar, and which itself changes to the adult moth. The adult oth then lays eggs as above stated, and the story begins with the egg ain.*

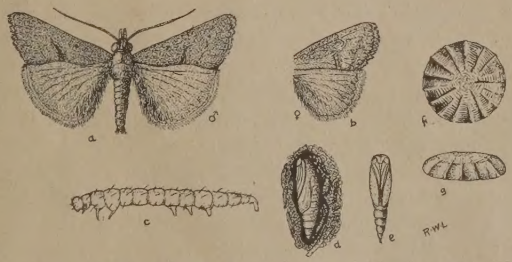

FIG. 1. Stages of Green Clover Worm: (*a*) male moth; (*b*) wings of female moth; (*c*) larva nearly full grown; (*d*) pupa in opened cocoon; (*e*) pupa exposed; (*f*) and (*g*) top and side view of egg. All natural size except egg, which is enlarged. (Original.)

Adult, or Moth.—The adult moth measures somewhat over an inch om tip to tip of expanded wings. Its general color is dark gray, own, or blackish. The male moth is larger than the female. The nder antennae (feelers) are about one-half inch long. The finger- e organs at the mouth (palpi) extend forward from the head, giving se to the name "snout-mouth," which is often applied to this and lated species. The moth has a slender, tongue-like organ through nich it can suck liquids, this being coiled beneath the head. The moths ate and lay eggs, after which they die, this being the one and only age of life in which death naturally occurs. The moths fly actively. male moth is shown, natural size, in Fig. 1, at (*a*); wings of female (*b*).

The Egg.—The egg is very small, flattened, but round in shape, and obed. It is shown greatly enlarged in Fig. 1, at (*f*) and (*g*). Its tual size is about that of a period in ordinary print. It is pale green nen laid, turning darker as it approaches hatching (or blackish if

*The idea that the worms develop from eggs of grasshoppers or beetles is wholly a mistake.

infested with egg-parasite). The eggs are laid on either upper or low surface of the leaves. The egg hatches in about five days to a sm caterpillar.

Larva, or Caterpillar.—When first hatched the caterpillar is less th one-eighth inch long; when grown, something over one inch. It shown in natural size, in Fig. 1, at (*c*). Its general color is green, son times pale, more or less striped with lighter color; it crawls with looping motion, and when disturbed can "jump" actively. It feeds a grows rapidly, this being the only stage of life which does injury. takes about 25 days from hatching to full growth, no doubt taki longer in cool weather. When grown it leaves the plant and craw under trash or rubbish or in cracks of earth and spins a fragile silk cocoon, mingled with bits of earth. In this cocoon it changes to t pupa.

Pupa, or Chrysalis.—This is the stage following the caterpillar, a this stage of life is passed in the fragile cocoon, or naked if the coco is worn away from weathering or other cause. The pupa is show natural size, with and without cocoon, in Fig. 1, at (*d*) and (*e*). T pupa is about one-half inch long, spindle-shaped, and brown in col It takes no food, merely going through the change to the adult mot and lies quiet, merely twisting the tail-portion if disturbed. It tak 11 days (in midsummer) to go through this stage of life, and then t moth, having developed inside, splits open the pupal skin and emerg

The moth (adult) has been described.

Generations, or Broods.—The destructive defoliation of our soybea in 1919 was done by one generation of the caterpillars. But it is we known that three or four generations are produced in a season. T length of time given for the stages is based on findings in August; would naturally be slower in cooler weather. The generations seem t be well defined, for the caterpillars with which we worked all mature at about the same time.

Wintering, Hibernation.—We have often found the adult moths c this insect alive in winter, under loose dead bark and like sheltere places. It is also stated that some pupae pass the winter, and it thought that perhaps only those which winter as pupae and emerge a moths in spring can reproduce.

Habits.—The moths show an inclination to seek shelter around ol buildings, sheds, etc. They fly freely and are not especially attracted t light. They apparently live for about a week before laying eggs.

The worms (larvae) crawl with a looping motion, can "jump" whe disturbed, and feed upon on either lower or upper surface of leaves, an in our outbreak ate entirely through the young leaves of soybean within a few days after hatching.

When grown the worms leave the food-plant and wander before enter ing the earth to spin the cocoon, at this time being often found on plant which apparently do not serve as food.

Natural Enemies.—There is no reasonable doubt that some of our birds feed upon this insect. At the time of the outbreak many kinds of predaceous beetles and bugs were common in the fields as if for the purpose of feeding upon them. One paper-nest wasp was seen feeding upon a worm. Of true insect parasites, which develop inside the egg, larva, or pupa of the Green Clover Worm, we reared several distinct kinds. One of these, which developed in the eggs of the Clover Worm, was so abundant as to help materially.

FIG. 2. Close view of soybeans (Mammoth Yellow variety), showing defoliation by Green Clover Worm. Only the ribs and veins remained, giving a lace-like appearance to the leaves. Terra Ceia, N. C., August 7, 1919. (Original.)

This very helpful egg-parasite* is one of the smallest insects known to science. Though the egg of the moth is only about the size of a period in ordinary print, yet this parasite attains its full development inside that egg, emerging from it full grown, with six legs, four wings, antennae, etc. Not only so, but we have had *three* of these parasites to emerge full grown from one egg of the moth.

REMEDIES

The principle is simple. These worms on soybeans attacked chiefly the younger of the grown leaves in the upper parts of the plants, when these were gone they would attack the very small unfolded leaves in the bud and the older leaves lower on the stalk, but they decidedly preferred the well expanded leaves near the top. Also they usually ate entirely through the leaf, and were often seen feeding from either the upper or

**Trichogramma pretiosa*, Riley; order *Hymenoptera*.

lower surface. (See Fig. 4.) This at once suggested the use of poison, after the same manner as commonly used for potato beetles and tobacco worms. The tests soon showed that this was effective, and not injurious to the growth of the plants, when dry arsenate of lead was used at the rate of 1 pound mixed with 8 pounds of dry dust lime (hydrated), and applied as a dust.* Greater strengths of the poison were not necessary, were more expensive, and did injury to the plants when applied by hand. We also found that Paris green is unsafe, as it is entirely too violent in its burning effect on foliage.

The early-maturing varieties were much more seriously hurt than the later-maturing ones. This point will be of importance if the insect should become regularly destructive at that season (July-August).

These several matters are more fully discussed below.

POISONING THE WORMS

At the beginning of the outbreak we had no adequate information as to the ease of killing the worms with poison, or whether the plants would be hurt by its application. Our tests soon gave light on these points.

The Poison.—In our tests we used *dry powdered arsenate of lead,* such as is much used by the best growers for spraying and dusting to control potato beetles, tobacco worms, orchard pests, and other leaf-eating insects. We mixed this with dust lime as explained below. This proved to be entirely satisfactory, and was, to our knowledge, used with good success by a number of growers. The material known as "cal-arsenate" was also used successfully, but most of our work was with arsenate of lead.

We tested Paris green and found that it was fatal to the plants, even when very much diluted; we had at all times advised against the use of Paris green. We did not test any of the ready-made preparations which are advertised for use against potato beetles, etc. As the whole outbreak was of very short duration, we concentrated our attention upon the material which was known to offer the best chance for good, and it was satisfactory.

Strength of Poison.—We mixed the dry powdered arsenate of lead with dry dust lime (hydrated), at rate of 1 pound of the arsenate of lead to 8 pounds of lime. This was the standard strength which we widely recommended at the time, and which proved to be entirely satisfactory. The method of mixing is simple: simply weigh out the amount of lime needed and place it in a tight empty box, sprinkle over and through it the required amount of powdered arsenate of lead, then

*In states further north two complications enter: (1) the worms have been destructive to garden snap beans, which, as the pods are eaten, renders the use of poisons objectionable; (2) on pole beans (perhaps snaps also) they usually feed from the underside, and do not eat all the way through, making it necessary to treat the undersides of the leaves. In our outbreak of 1919 these factors did not enter—the attack was concentrated chiefly on soybeans, on which they ate entirely through the leaves—and as the plants were yet due to remain many weeks in the field the poison could be safely used.

oroughly mix the two by stirring and shovelling back and forth with ick, paddle, shovel, or other implement; the mixing must be thorough, r the poison, which constitutes only one-ninth of the whole, must be oroughly distributed through the whole mass of material.

Applying the Dust.—Applications were made by hand, and with dust- owers operated by hand, and in both cases the results were good. The ork can be done more rapidly and with less waste of material with the achines. There was no opportunity to test the larger, horse-drawn owers, which treat several rows at once, but these would do satisfactory ork, and more rapidly.

The hand applications were made by merely sifting the material rough the fingers, swinging the hand through the tops of the plants, us developing enough current of air to aid in distributing the dust to l parts of the foliage. As this method involves the use of more aterial than is really necessary, we would strongly advise against using e mixture stronger than 1 to 8 in hand applications, not only because is wasteful, but because the greater strengths, when applied by this ude method, are likely to injure the plants.

The machine applications were made with the type of blower that is apped to the body, operated by a crank, and blows the dust through metal pipe an inch or more in diameter, throwing it on the plants in thin, cloud-like blast. As this method uses much less of the material, eater strength can be used if desired. We know of the powdered senate having been used pure (no lime) with dusting machine with- t serious injury to the plants. There is a slight advantage in using e more concentrated strength when it can be safely done as with the achines; it saves in lime, which is one small item, and it saves in the lk and weight of materials handled. However, even with the ma- ines, we believe it would be better not to use it stronger than 1 pound arsenate to 4 pounds of lime. We think it would be of advantage consider "1 to 8" as the standard formula for this pest on soybeans, ecially so as that same strength of same materials can be successfully d against potato beetles, tobacco worms, and others, including cabbage rms in gardens.

How Much Per Acre?—Our observations lead us to conclude that with bean plants in rows, averaging one foot high, two pounds *of the ison*, evenly distributed, will check the injury on one acre. This ans that when using the 1 to 8 mixture it would take about 18 pounds the mixture for an acre. Machines can be geared to distribute that ount over an acre, but hand applications would require more. By same calculation, if one were using 1 to 4 mixture with machine, pounds of the mixture would do for an acre, and the machine could geared accordingly.

If applying the 1 to 8 mixture by hand, use just as little as necessary get a coloring of the dust thoroughly over the upper expanded leaves

of the plant. To do this by hand will require more material than really needed, owing to unevenness.

In our work of 1919 we found that the preference of the worms f the upper expanded leaves, coupled with the fact that they ate entire through the leaves, greatly simplified the task of poisoning them. we merely gave a thorough dusting to the upper one-third of the pla enough of the poison sifted down (partly due to the already riddl condition of upper leaves) to give sufficient protection to the older a tougher leaves below, and we did not find it necessary to make a special effort to reach the lower surfaces of the leaves. Indeed, t whole matter of applying the mixture was much the same as for pota beetles—a prompt application in an approximately even distributi was effective. Of course, the aim should be to apply it thoroughly, y without waste.

Promptness is Important.—In the 1919 outbreak the first complain were in the last days of July, and the attack had subsided by the midd of August, only that one generation of the worms doing serious har for the season. The great bulk of the damage was done during t space of two weeks. It can easily be understood that in such a sho intensive outbreak, the utmost promptness is essential. If a farm waited to send specimens to some office for identification and advic and then had to order the materials from some distant point, the dama would be well-nigh over before any application of remedies wou be made.

Watchfulness.—As it takes about 25 days for the caterpillars t become grown, it is certain that the destructive brood which mature about August 12 (average) began their destruction about July 1 although they were not complained of until two weeks later. Ther was, therefore, an interval of two weeks during which this horde o worms was growing through their younger life, feeding on the foliag of the soybeans. Any farmer who had been so watchful as to dete them earlier (say by July 25), and so prepared as to apply poiso thoroughly by July 28 (the time when the first complaints began) would certainly have prevented the greater part of the injury.

Preparedness.—It is gratifying to know that more and more farmer orchardists, and truckers are learning the proper use of arsenate of lea and other materials against insects, and that this is causing more mer chants to carry stocks of the standard materials. In every year potat beetles, cabbage worms, tobacco worms, and other leaf-eating insects d much damage in crops, gardens, and orchards. Surely there should b enough regular demand for arsenate of lead so that there would b some of it in every county through the growing season, and farmer should so understand its use that in an outbreak of this kind they coul proceed in such manner as to get results, even if the insect were a new one to them. We have made the following statement to thousands of

farmers at hundreds of farmers institutes throughout the State: "An insect which feeds openly and exposed and does its damage by eating the leaves off the plant, is killed by the use of poison after the same general manner as the potato beetle, there may be differences in details, but the general principle is the same."

Effect on the Worms.—Besides observing that the application of the "1 to 8" mixture killed the worms in the field, and gave profitable results when promptly used, we also tested it on worms confined in cages under close observation. We found that when confined with plants which had received treatment the same as those in the field, the worms immediately fed much less, the mere presence of the dust seemed objectionable to them. When they did eat they soon died, virtually all being dead within four days after the poison was applied, and they did not die of natural cause, nor starvation, nor parasites; they died with every evidence of *poisoning.* They had fed only a very little in the meantime, not enough to seriously damage the foliage in the cages, yet they *died,* they did not mature to moths, they left no offspring. Only an occasional worm, which was already about grown, managed to spin its cocoon, go through the pupa stage, and emerge as a moth. The protection to the plants was entirely satisfactory.

There would be some advantage in using a poison which would act quicker than arsenate of lead. Calcium arsenate fills this requirement, and with long-continued tests it might have been found even superior to the arsenate of lead, for we know that it was successfully used. But as our tests were chiefly with the arsenate of lead, and as these tests were abundantly satisfactory, we confine our discussion to the facts as found.

Effect on the Plants.—On August 8 we dusted well grown soybean plants with the "1 to 8" arsenate mixture by hand, as would be done in field practice. Observed for over a month, the plants showed no injury whatever in comparison with untreated ones alongside.

On August 8 we dusted other soybeans with the same "1 to 8" mixture by hand, using several times more of the material than there was need for, to see if a carelessly heavy and wasteful application would injure the plants. There was only very slight and temporary injury.

These several tests proved that the "1 to 8" mixture is entirely safe.

We tested it at the rate of "1 to 4" by hand, and it injured the foliage; also "1 to 2," which injured more, each step in greater strength increasing the injury, until when we used it pure (no lime) the injury was worse than that done by the worms.

We must regard the "1 to 8" (1 pound of powdered arsenate of lead to 8 pounds of dust lime) as the standard, especially for hand applications.

Safety of Hay.—Circumstances prevented tests of feeding treated plants to livestock. Important as this question seemed at first, it held less and less of interest as our work proceeded. Plants dusted August 8

showed very little evidence on September 11, and as only one-ninth of the material applied was actual poison, the possible danger seems too remote for consideration. Normal harvest was still one or two months away, by which time it is practically certain that all serious danger would have been removed. As time went on, the material disappeared from the plants, the question seemed to have become trivial; farmers, who at first questioned, took the same view; they have ignored the fact that poison was ever applied, and we have not heard of any bad results.

FIG. 3. A 15-acre field of soybeans (*Virginia* variety) almost entirely defoliated by the Green Clover Worm. The beans were planted in rows for seed. Less than five bushels of seed per acre were harvested. The yield should have been 35 bushels per acre. Latham Farm, Belhaven, N. C., August 1, 1919. (Original.)

Cost.—We estimate that for labor and materials it should not cost more than two dollars per acre to give an effective application to control the Green Clover Worm in soybeans, with plants the size that most of them were in early August, 1919.

Machines.—The hand-duster used by us in our tests was strapped on the body, worked by a crank, and blows the dust through a metal pipe an inch or more in diameter, the end of the pipe being about 3 feet in front of the operator. Other kinds are on the market.

Where is Dusting Practicable?—It would be difficult, if not profitless, to undertake to thoroughly dust beans which are growing broadcast, tangled in cornstalks, many of which are leaning or prostrate. On the other hand, when they are grown in rows it is as simple as to treat potatoes for potato-beetles. Between these extremes every farmer can use his own judgment as to the practicability of using the poison-dust treatment if the Green Clover Worm at any time becomes a pest.

We wish to again emphasize that the "1 to 8" mixture is safe, practicable, and effective, when the beans are grown in such manner as to get at them. We could quote from well known farmers who have declared that with the arsenate mixture the control of this pest is a solved problem.

VARIETIES

In the Green Clover Worm outbreak of 1919, we found that different varieties of soybeans varied greatly in the injury sustained. The de-

FIG. 4. Green Clover Worm, and its work on leaf of soybean. (Original.)

structive brood of caterpillars did their maximum damage the first week in August. At that time, the early-maturing varieties, like Ito San, Virginia, Black-Eye-Brow, and Black Wilson had practically finished their growth of stalk and leaves, had bloomed and formed pods, but had not matured the beans. When the worms stripped them of their foliage they could not renew it, the plants withered and had to be cut for what hay they would make, such beans as were made being light and immature. On the other hand, the later-maturing varieties like Tokio and Mammoth Yellow had not finished growth of stalk and foliage, in many cases had not yet bloomed, and when stripped of their leaves in this short intensive outbreak they quickly put out new foliage as soon as the damage ceased, bloomed, and matured their beans. The maturing of the crop was delayed—"latened" as several expressed it—and probably the yield was not as heavy as it would otherwise have been, but the damage was not nearly so great as with the earlier varieties.

No one can foretell whether this insect will often recur in such num-

bers as to be a pest, nor whether its greatest destruction will always be at the same season. It does seem to be an insect whose midsummer brood is most likely to be destructive; hence, if there should be future outbreaks we would expect them at about the same season. Only time and experience can show whether there will be any occasion to choose varieties of soybeans with reference to injury by the Green Clover Worm. In any case the "1 to 8" mixture offers an easy protection if promptly applied.